Profitable New Aerospace Technology With Potential Industrial Applications

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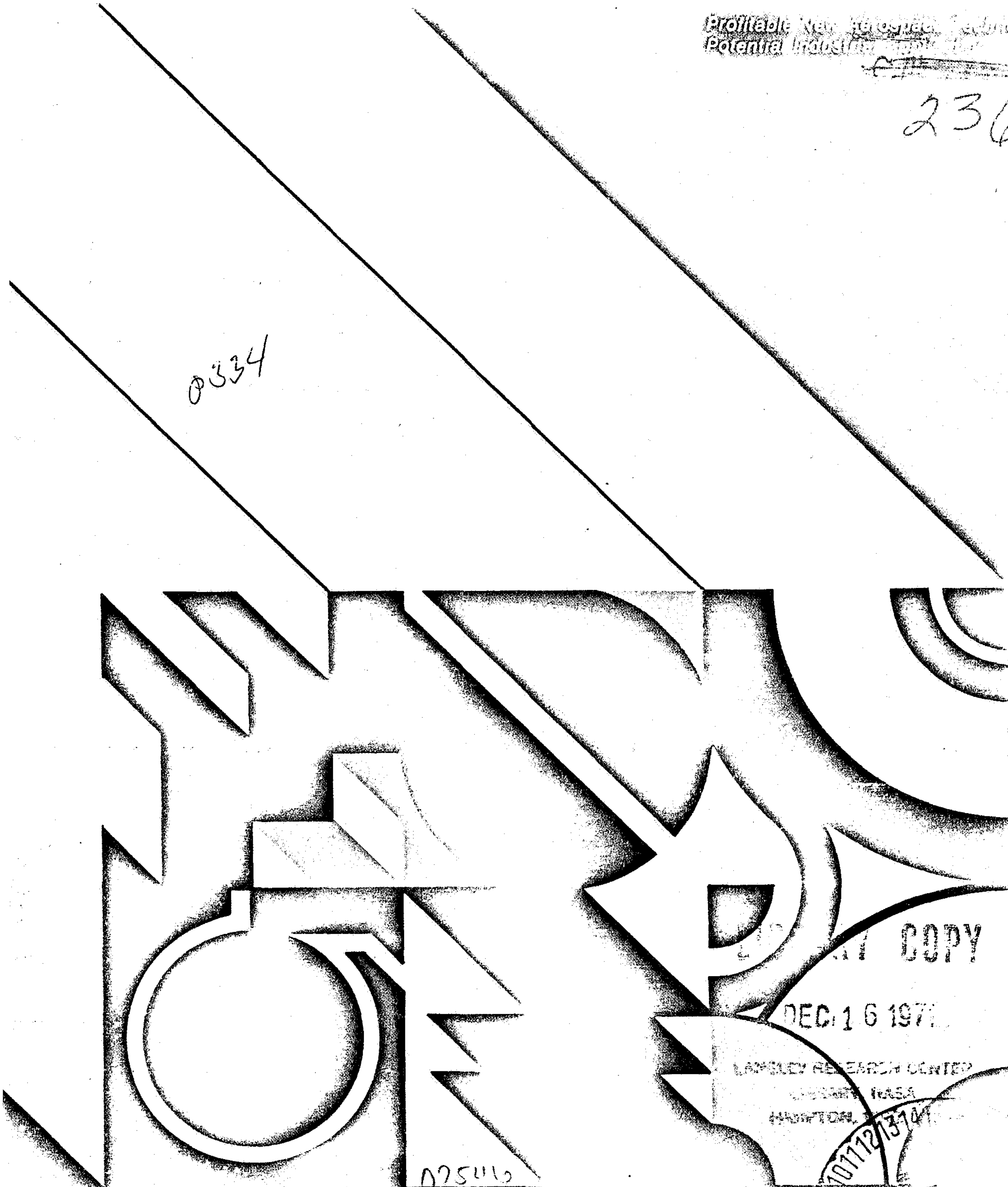

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Testing Methods and Techniques Quality Control and Nondestructive Testing

National Aeronautics And Space Administration

Small Business Administration

(NASA-TM-X-72337) TESTING METHODS AND TECHNIQUES: QUALITY CONTROL AND NONDESTRUCTIVE TESTING (NASA) 31 p

N75-70750

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NASA/SBA TECHNOLOGY BENEFITS BUSINESS AND INDUSTRY

- A Colorado company has put NASA-developed testing and inspection procedures for process control of monolithic circuits to profitable use. The technology, first employed at Marshall Space Flight Center, provides quality assurance procedures for mass production of high reliability integrated circuits at competitive costs. A company manager estimated that a $6,000 dollar saving has been realized while product quality has been improved.

- A torque meter developed for Marshall Space Flight Center enabled a Midwestern electronics company to save $10,000 in producing a low-cost, high-volume military product. The development also enabled the company to produce a related product with greater efficiency.

- Obtaining a nonexclusive license from NASA, another Midwestern manufacturer produced a slightly modified version of a heat flux sensor, originally developed for the Manned Spacecraft Center, at a $24,000 saving to his customers in the first sales year.

- A West Coast manufacturer was able to dispense with costly techniques for testing bellows assemblies by applying procedures described in a Marshall Space Flight Center Tech Brief. A Midwestern manufacturer, using the same information, stated that its designers were aided in determining failure causes and in improving product quality.

READER SERVICE CARD (NASA/SBA No. 1)

TESTING METHODS AND TECHNIQUES: QUALITY CONTROL AND NONDESTRUCTIVE TESTING

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FOREWORD

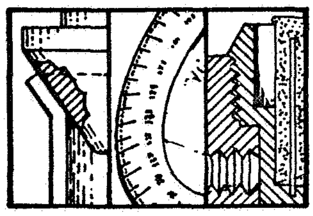
Your firm's ECONOMIC GROWTH can be INCREASED through the use of new and improved MATERIALS, EQUIPMENT, and PROCESSING METHODS developed in the aerospace industry. The R & D successfully applied by the aerospace community can help you LOWER UNIT COSTS, IMPROVE COMPETITIVE POSITION, DEVELOP NEW PRODUCTS, and INCREASE THE PROFITS of your firm. By assisting you in realizing these goals, NASA's and SBA's Technology Utilization Programs are making multiple application of results of this research and development and earning for the public an increased return on their investment in aerospace programs.

Additional technical information on testing methods and techniques can be requested by circling the appropriate number on the Reader Service Card included in this compilation.

Unless otherwise stated neither NASA nor SBA contemplate any patent action on the technology described.

CONTENTS

SECTION 1. PHYSICAL INSPECTION



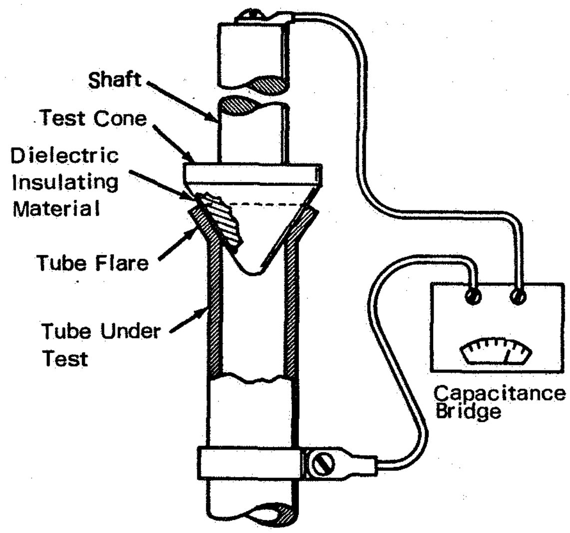
PORTABLE TOOL FOR TESTING TUBE FLARES

A flared-tube gage, fitted with a precisely tapered test cone, can determine the accuracy of tube flares efficiently and economically. Previous methods of tube flare inspection required complex instruments, considerable time, and supplementary visual inspection.

As shown in the figure, the gage consists of a test cone and shaft, and a capacitance-bridge meter. The test cone, tapered to complement a particular flare, is coated with a thin, uniform, dielectric surface layer. To test a tube flare, the meter is connected to the shaft and to the tube, then the cone is placed in the flare in mating position. Imperfections in the flare cause an improper fit between the test cone and the inside flare surface, and lower the capacitance indicated by the meter. The conceptual design of the gage has not been reduced to hardware status.

Additional details are contained in U.S. Patent No. 3,426,272, which is available from U.S. Patent Office, price $0.50.

Source: F. D. Griffin
John F. Kennedy Space Center
(KSC-66-19)



MECHANICAL GAGE CHECKS ROUNDNESS AND CONCENTRICITY OF TUBE FLARES

Another gage, capable of checking tube-flare roundness and concentricity with an accuracy of 2.5 μm (0.0001 in.), can be constructed using standard toolmaking supplies. The gage is assembled on a precision-ground base. An X-Y table, equipped with vernier micrometers for position control, is mounted vertically and fitted with a V-block pipe clamp. A heavy-gauge channel section is mounted parallel to the table, bored and fitted with two precision drill bushings. An oil-hardened, nondeforming tool-steel spindle is passed through the bushings. A precision dial indicator is mounted on the end of the spindle, a short distance from the V-block.

The tubing to be tested is clamped in the V-block. The X-Y micrometers are used to accurately position the flare with respect to the indicator probe. By rotating the spindle while the probe is successively in contact with the flare surface, the flare section, and the tube interior, readings may be taken from which the tube and flare roundness and concentricity may be computed.

Source: L. K. Clark of
International Business Machines
under contract to
Marshall Space Flight Center
(MFS-1822)

Circle 1 on Reader Service Card.

REMOTE INSPECTION OF INTERNAL IRREGULARITIES IN PIPING

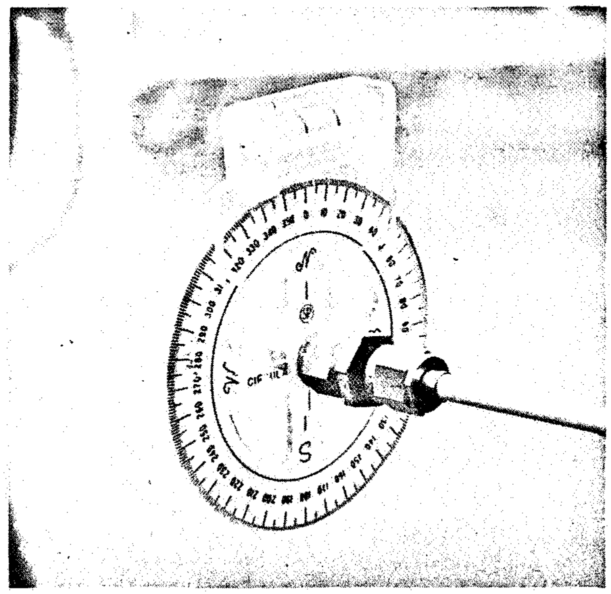
An electromechanical probe bearing a closed-circuit TV camera can enter medium-diameter (14-20 cm) piping and visually inspect offset and peaking of welds.

The probe was designed for inspection of vacuum-jacketed liquid lines that cannot be inspected externally. Radial welds are located visually, using the closed circuit TV system. The TV camera is located in the forward section of the probe and aligned with a scanning mirror. When a weld is sighted, the probe is moved into position and locked in place by a pneumatically controlled, segmented shoe. A profile-tracing tool is extended to the surface of the weld and rotated; its shaft's axial motion is translated into a signal representing the weld profile.

Source: J. Y. Cunningham, F. H. Burry,
R. M. Heisman, L. B. Norwood, and
W. F. Iceland of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14545)

Circle 2 on Reader Service Card.

GAGE MEASURES TUBE BEND ANGLES



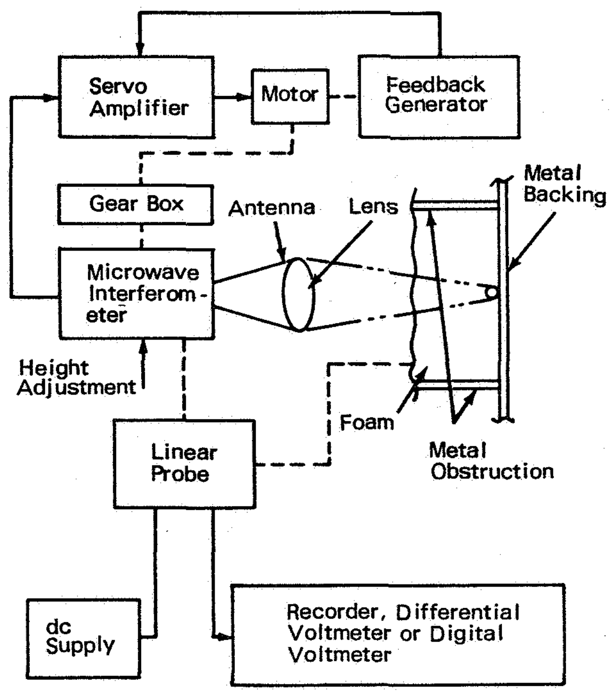
The figure shows a specially developed protractor being used to rapidly measure the rotation angle between successive tubing bends. In making prototype tubing assemblies, hand tube benders are often used. Large instruments have been required for measuring the tubing rotation angles, in order to program the production of duplicate parts.

The new device is a small portable protractor and levelling device. The protractor, mounted on a central shaft, is fitted for attachment to a length of tubing. A plastic bracket can be rotated to align a hairline with the desired protractor setting. The bracket also carries a level bubble, so that the hairline can be set to vertical.

Source: C. W. Seiple of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15545)

No further documentation is available.

MICROWAVE INTERFEROMETER MEASURES FOAM INSULATION THICKNESS



The illustrated microwave interferometer system can be used to determine the thickness of sprayed foam insulation in areas close to metal obstructions. The interferometer unit provides input to a servo loop, which maintains a constant distance between the interferometer unit and the metal surface.

A mechanical gage measures distance from the interferometer to the foam surface. The gage consists of a linear potentiometer attached to one end of a spring-loaded probe, the other end of which rides on the foam surface.

Source: W. F. Iceland of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16599)

Circle 3 on Reader Service Card.

TECHNIQUES FOR LOCATING LOW-DENSITY FOREIGN OBJECTS IN HEAVY METAL PIPING

A comparative study has been made of four techniques for detecting low-density foreign objects trapped within heavy metal plumbing. Conventional, direct X-ray techniques cannot detect objects composed of such materials as wood, cloth, plastic, or rubber, through a high-strength alloy plate 1 cm or greater in thickness. The four techniques and their relative features are as follows:

Negative Radiography:

A heavy, X-ray absorbing liquid is used to create a negative radiographic image. When a low-density material is surrounded by the liquid, the radiograph reveals an apparent void within the shadow of the liquid.

Neutron Radiography:

Neutron radiographic procedures are similar to those used in X-ray radiography. However, while X-ray provides shadowgraphs of dense materials, neutrons penetrate the majority of dense materials and make shadowgraphs of most low-density substances. The contrast and resolution obtained with this technique for organic materials are equivalent to those obtained by X-raying metallic structures.

Liquid-Crystal Inspection:

A means of detecting small temperature changes on the surface of a material, this technique can reveal hot spots, temperature differences caused by coolant tube blockage, or moving temperature fronts. Liquid crystals, cloudy, white, greasy, cholesterol materials, can be thinly coated on blackened surfaces. Vivid color reflections appear as the surface passes through a specific, narrow temperature range. The process is reversible and repeatable.

Ultrasonics:

A focused, high-frequency sound beam is generated by an ultrasonic transducer in water. The beam passes through the tube wall and through the water filling the tube, reflects from the back wall of the tube, and returns to the transducer. The returning portion of the sound beam is selected by electronic gating and recorded. When tube blockage prevents transmission of the beam, no return signal is recorded.

The conclusions of the evaluation program are that functional flow tests should be performed first, then X-ray. If flow tests reveal a blockage and the responsible objects cannot be detected by X-ray, negative radiography is a highly effective, low-cost alternative. If a flow test still indicates undetected blockage, neutron radiography is advised. The liquid-crystal inspection method can also be applied to determine the cooling efficiency of accessible coolant-system surfaces.

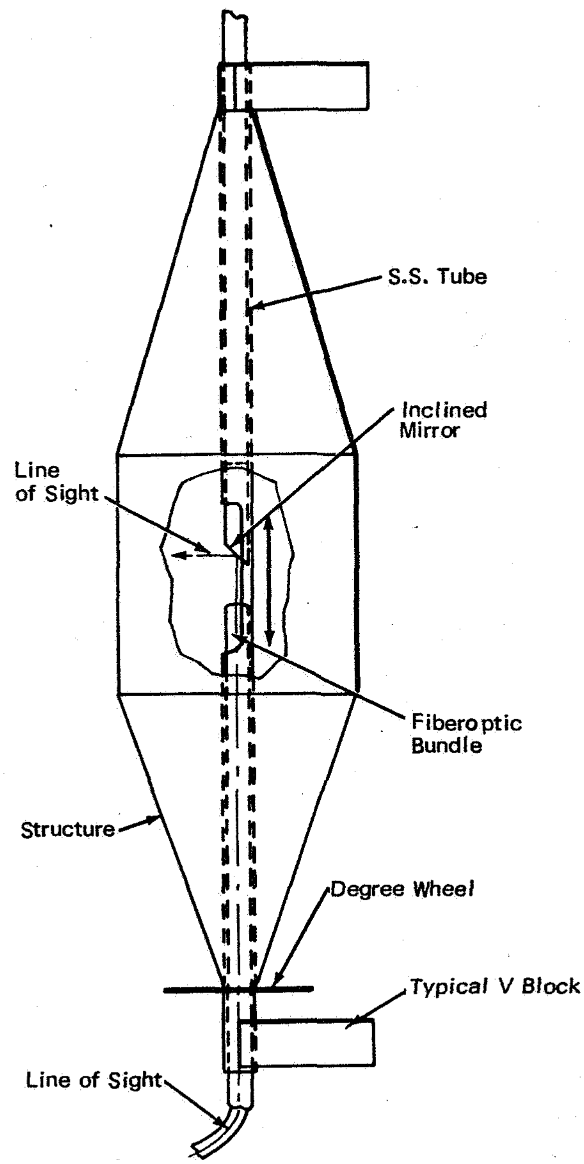
Source: J. A. Hendron of
Aerojet General Corp.
under contract to
Space Nuclear Systems Office
(NUC-10386)

Circle 4 on Reader Service Card.

VISUAL INSPECTION OF LIMITED-ACCESS INTERIOR SURFACES

The figure illustrates the use of a special-purpose probe that permits inspection of restricted-access interior surfaces and precise location of any discontinuities observed. Developed for inspecting hollow, graphite-epoxy composite structures, the probe is essentially a fiberoptic bundle mounted in a length of stainless steel tubing. A hole is machined into the tube just past the end of the bundle and a mirror is inserted, mounted at an angle of $\pi/2$ rad (45°) to the axis of the tube. The fiberoptic bundle thus views a small sector perpendicular to the tube. The bundle is connected to external optics, providing a probe with a focal length from 0.63 cm to infinity, and a magnification from 1 to 50 ×.

The tube is passed through the tapered cylindrical structure and supported in V-blocks at each end. With the probe thus supported in a fixed position relative to the structure's central axis, rotation of the strut enables observation of a cylindrical segment



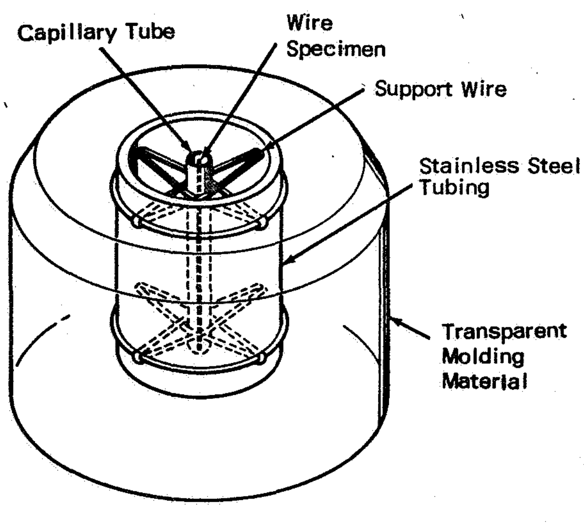
of the structure. Translation of the tube changes the location of the viewed segment, thus permitting the entire interior surface to be inspected. Further, by calibrating the length of the tube and the circumference of the structure, the cylindrical coordinates of any observed flaw can be recorded.

Another innovation, used in ultrasonic testing of the same structure, is described in Section 2, as item MFS-21360.

Source: G. H. Leinbaugh and G. W. Kurtz
Marshall Space Flight Center
(MFS-21373)

Circle 5 on Reader Service Card.

FINE WIRE SPECIMENS MOUNTED IN CAPILLARY TUBE FOR INSPECTION



The illustrated capillary-tube wire holder simplifies the polishing and metallographic inspection of fine (0.01 mm) wires. Where formerly such specimens were cast in solid blocks, and frequently lost or damaged, the new mounting technique protects the wire from damage and makes it easy to locate.

The mount is made from a 0.75-mm-diameter, 2-cm-long capillary tube, mounted within a stainless steel tube 1-cm in diameter. Eight 1 mm holes, four at the top and four at the bottom, are drilled in the stainless steel tube, and wires are strung, suspending the capillary along the axis of the larger tube. The fine wire specimen is inserted in the capillary tube and the whole construction is encased within a transparent casting material.

Source: H. A. Raphael of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-358)

No further documentation is available.

ACOUSTIC MONITORING FOR MECHANICAL CHECKOUT

The motion of mechanical components generates vibrations, sonic signals that can be detected and converted into electrical signals. Such signals can often be correlated with component condition. They have been used, for example, to enable accurate valve timing. The sonic-signal analysis technique has the particular advantage that it does not require disassembly of the tested component.

In developing the theory of mechanical checkout by acoustic monitoring, the equipment and techniques used for sonic signal acquisition and analysis have been explored. The ultimate objective has been the design of automated equipment to perform signal analysis and provide both qualitative and quantitative readouts.

The program has demonstrated that acoustic monitoring provides a powerful tool for mechanical component checkout and failure analysis. The technique also provides the ability to predict component failures in advance, by detecting incipient malfunctions. Analysis of a component's sonic signature can yield valuable information about its operation, even without comparison to previous sonic signatures. Thus, the technique can be used even with one-of-a-kind items, for testing, for failure analysis, and for development of quality standards and test procedures.

Source: C. Savelle
Marshall Space Flight Center
(MFS-13372)

Circle 6 on Reader Service Card.

ULTRASONIC POSITION SENSOR

An ultrasonic position sensor originally designed for use in vibration testing the Saturn V launch vehicle can measure and display horizontal displacements from 0 to 13 cm out of a total distance of 120 cm, with a tolerance of ± 2 mm. The ultrasonic system was selected in preference to an rf ranging system for various reasons, including less complex design, lower cost, higher reliability, and lower chance of interchannel interference.

The system employs four sets of paired transmitting and receiving transducers, positioned quadrilaterally around the test object and separated from it by a distance of approximately 120 cm. A single 250 kHz ultrasonic generator drives all four transmitters; individual range units are used for each receiver. A gate generator controls the transmitter pulse width and provides blanking gates for the receivers. The gate generator is triggered by a pulse-recurrence frequency generator, which also controls the four range units.

The output of each range unit is an analog voltage that represents the range between one receiver and the test object. Two difference amplifiers compare the range voltages of the associated channels on opposite sides of the test object. The output of each difference amplifier represents the deflection of the object in one dimension. This system can be used to determine the position or alignment of an object during vibrational and similar environmental testing, particularly when mechanical attachment to the test object is to be avoided.

Source: J. R. Dettman, R. E. Bedard,
and W. O. LeDrew of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-1412)

Circle 7 on Reader Service Card.

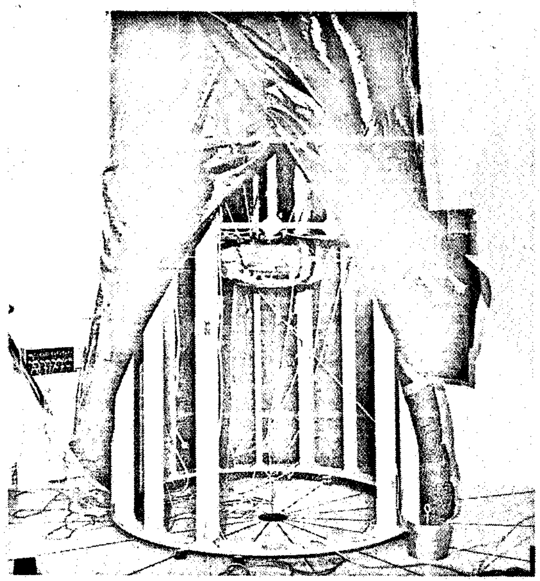
PLASTIC SHROUD FOR ACOUSTIC TESTING ATTENUATES HIGH-FREQUENCY DISTORTION

Undesired, high-frequency, nonelectric noise in acoustic test spectra can be attenuated by using a sealed shroud, made of multiple layers of polyethylene plastic, to surround the test object.

In acoustic testing within a reverberation chamber, a number of effects combine to produce high-frequency noise components in the acoustic energy applied to the test object. One source is harmonic generation in the test chamber; another is distortion caused by the non-linear transfer characteristic of the atmosphere used as a transmission medium; a third is noise generated by passage of air or nitrogen through the horn throat and modulation valve.

These high-frequency noises are difficult to control electrically. However, by enclosing the test object in a shroud made of multiple layers of polyethylene film, the undesired noise frequencies can be attenuated.

The figure shows the shroud configuration. The cylindrical, wooden frame is mounted on casters so that it can be readily shifted within the test chamber. Four layers of 250 μm (10 mil) polyethylene film form a cylindrical shroud with an internal volume of 6.05 m^3 (216 ft^3). A slit opening in each layer is closed with a heavy duty zipper. The bottom edges of the shroud are sealed to the chamber floor with pressure-sensitive tape. The test object is suspended within the frame on a length of bungee cord.

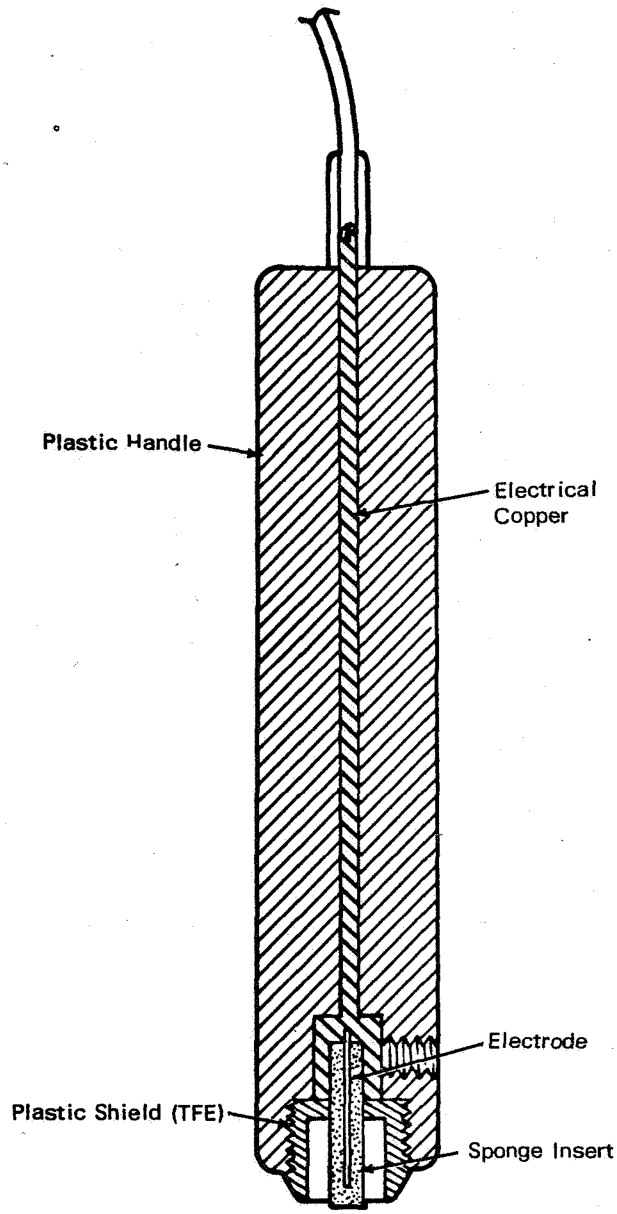


Source: R. C. Woodbury of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11260)

Circle 8 on Reader Service Card.

ELECTROCHEMICAL ALLOY VERIFICATION

The illustrated probe is the heart of a simple device for nondestructively testing parts and weldments to assure that they are formed of the proper alloy. As shown, the probe consists of an electrode surrounded by a sponge insert, mounted in a plastic handle and connected to a single copper wire. A plastic shield insert fixes the electrode and sponge within the handle, and prevents direct contact



between the electrode and the part being measured.

For use, the probe is connected to one terminal of a high-impedance millivoltmeter, and the other terminal is grounded to the metal part to be tested. The sponge is then wet with an appropriate electrolyte and the probe is placed in contact with the metal surface.

The electrochemical voltage thus measured can be used to identify the metal under test.

Two methods of use are possible. First, the electrode may be made of a noble metal and the measured voltage used to determine the test alloy. Second, the electrode may be made of the desired alloy, and a null voltage used to indicate acceptance of test alloy.

Any mild ionic solution that does not attack the test materials too rapidly may be used as an electrolyte. Possible candidates include organic acids, weak bases, and various salts dispersed in silica gel.

Source: F. A. Jennings of
North American Rockwell Inc.
under contract to
Marshall Space Flight Center
(MFS-18652)

Circle 9 on Reader Service Card.

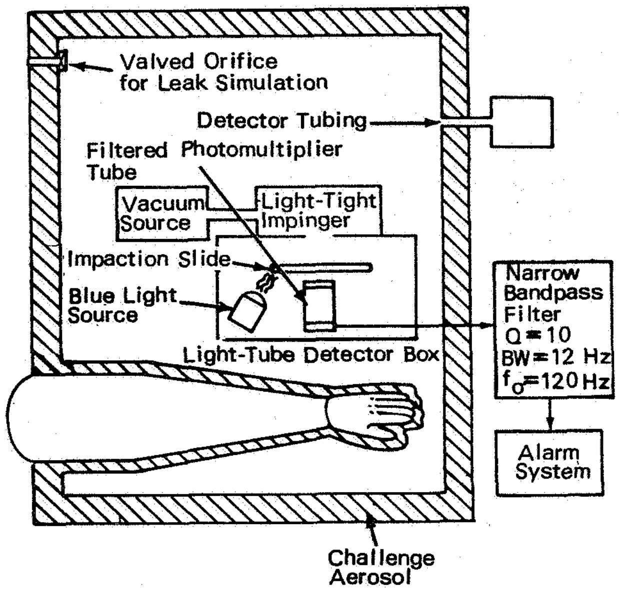
FLUORESCENT-PARTICLE CHALLENGE FOR STERILE ASSEMBLY FACILITY

The figure shows a double-walled, sterile-assembly glovebox that uses a fluorescent-contamination detection system. The particles, generated as an aerosol from aqueous solution, have approximately the same diameter as bacteria (0.3 to 2 μm). During use of the glovebox, a particle concentration of 3500 per cc is maintained in the space between the two walls. A slight positive pressure is also applied to aid in leak detection.

The detector proper is a simple glass slide, illuminated by a blue fluorescent light source and placed in front of a photomultiplier tube window. A filter on the window attenuates the reflected blue light, but passes the particles' fluorescent wavelengths. A 120-Hz narrow bandpass filter in the photomultiplier output circuit attenuates the response due to ambient illumination, but passes the particle-fluorescence signal into a threshold detector and alarm system.

Source: C. Aldridge of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-12822)

Circle 10 on Reader Service Card.

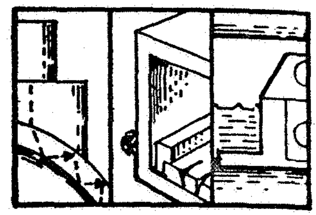


MAGNET ENABLES LOCATION OF APPARATUS THROUGH BULKHEAD

In X-ray inspection of large permanently installed metal plates, adding a magnet to the front end of the X-ray unit permits its precise location to be determined from the other side of the bulkhead. This allows shielding to be placed more accurately, and reduces the radiation hazard for personnel in the area.

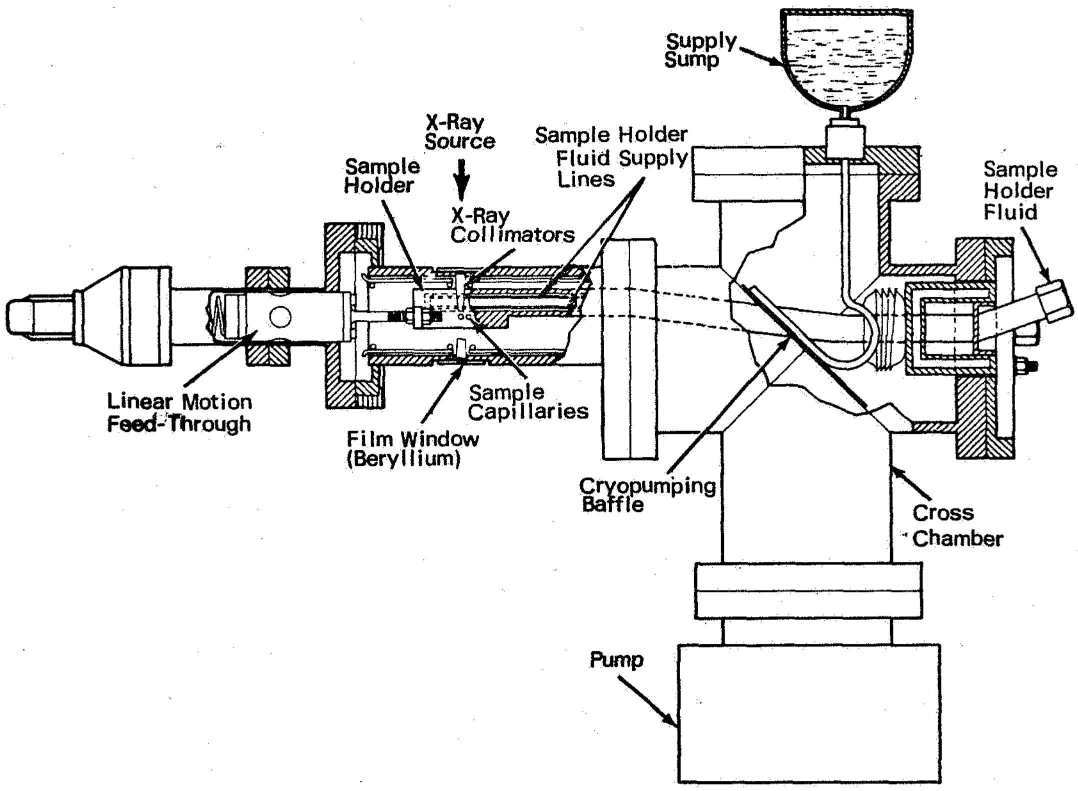
Source: G. T. Card of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12845)

No further documentation is available.



METHOD FOR X-RAY STUDY UNDER EXTREME TEMPERATURE AND PRESSURE CONDITIONS

The modified environmental simulation chamber shown in the figure provides the desired conditions for testing various materials' stabilities under extreme environmental conditions. Originated for studying mineral stability in lunar or spacecraft environments, the apparatus enables the sequential X-raying of multiple specimens, under temperatures



ranging from 90 to 400 K and pressures ranging from atmospheric down to 10^{-8} N/m^2.

A 500 liter/sec ion pump is used to create the desired vacuum. The environmental simulation system is set up in a 15.2 cm (6 in.) diameter cross chamber with the ion pump attached as shown. Samples are positioned by a micrometer, which is connected to the sample holder by a bellows-sealed, linear-motion feed-through. The bellows insulates the test chamber from undesirable temperature gradients.

Temperature is controlled by fluid conductive heat transfer (cryopumping). A suitable cryogen (LN_2) is maintained in a supply sump. From this supply, lines carry the liquid to the cryopumping baffle, where it cools the sample-holder fluid. This secondary fluid then circulates through the sample holder. A level control system provides a constant-head, gravity feed cryogen flow to the baffle. This system avoids varying flows that create intolerable fluctuations in the chamber pressure.

The samples themselves are sealed in glass capillaries and inserted in the stainless steel sample holder. The X-ray camera housing includes a thin beryllium strip window, which permits diffracted X-rays to reach the recording film.

Source: L. L. Paus of
Bendix Aerospace Systems Div.
under contract to
Manned Spacecraft Center
(MSC-11232)

Circle 11 on Reader Service Card.

SIMPLIFIED RADIOGRAPHIC TECHNIQUE FOR DETERMINING DEPTH

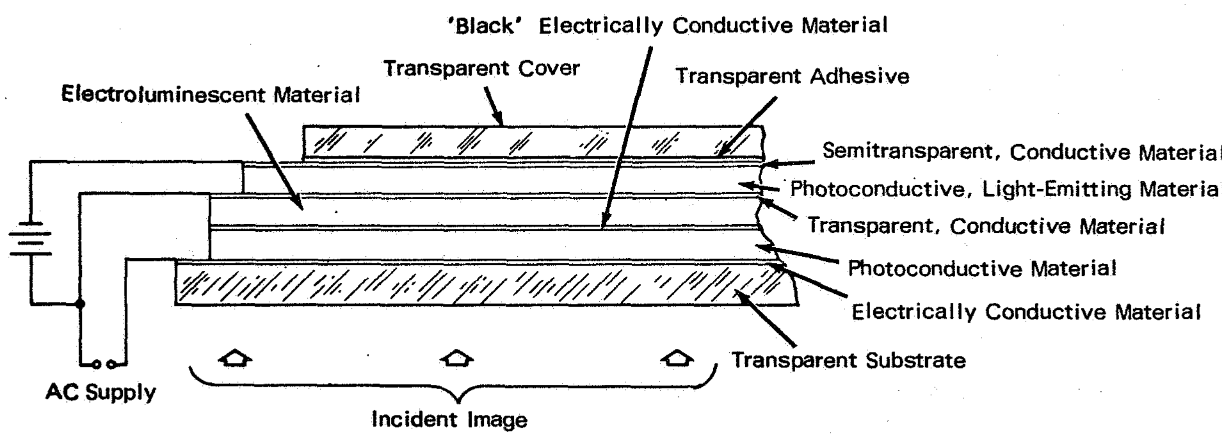
The depth of flaws revealed by X-ray radiography can be easily determined using a double exposure technique. The first exposure is made with the X-ray beam perpendicular to the surface, and the second is made at any other known angle. The image shift of the flaw can then be used to compute the depth of the flaw. Unlike other published depth finding methods, this technique uses no relative triangle. It thus has a potential for greater accuracy.

Source: F. E. Sugg of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16906)

Circle 12 on Reader Service Card.

RADIOGRAPHIC IMAGE AMPLIFIER

The layered image amplifier shown in the figure offers a number of advantages over conventional devices used for radiographic image amplification. The illustrated device is of relatively simple construction and provides higher contrast, better resolution images, over longer storage periods than are attainable with previous solid-state image amplifiers. The device also combines very high radiation sensitivity with fast image buildup and erasure capabilities. These characteristics are achieved by adding a layer of material that is both photoconductive and light-emitting to a basic image amplifier, and cascading the assembly.



The complete image amplifier panel consists of a number of layers, as follows: (1) a transparent substrate; (2) an electrically conductive, tin oxide film, which is transparent to the incident radiation; (3) a photoconductive film (typically activated cadmium sulfide or cadmium selenide); (4) a "black" electrically conductive material, which blocks any light emitted by the upper layers from leaking back into the third layer; (5) an electroluminescent film, which emits visible light when passing electric current; (6) a semitransparent, electrically conductive film (such as a thin film of gold or platinum); (7) a material that is both photoconductive and light-emitting; (8) a semitransparent, electrically conductive film; (9) a transparent adhesive film; and (10) a cover of transparent material, through which the radiographic image formed in the seventh layer can be viewed.

Source: R. L. Brown, Sr.
Marshall Space Flight Center
(MFS-14522)

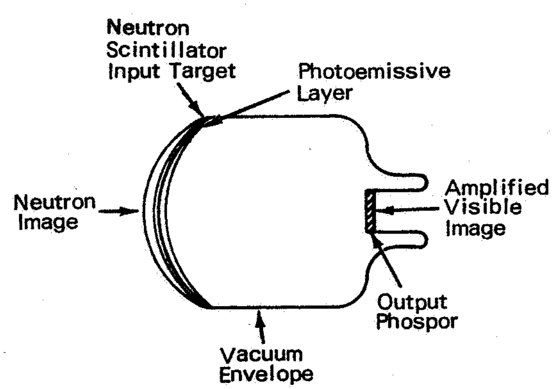
Circle 13 on Reader Service Card.

THERMAL-NEUTRON IMAGE INTENSIFIER

A vacuum-tube image intensifier improves image detection in thermal-neutron radiographic inspection. Neutron radiography can provide useful images of materials that are not easily X-rayed. However, sufficient image intensification must be obtained to permit the use of commercially available nonreactor neutron sources. The image should also be made bright enough to enable fluoroscopic viewing without dark adaptation. A system for observing motion in the neutron radiographic image is also desirable.

The tube shown in the figure consists of an input target (a combination of a neutron scintillator and a photoemissive layer) and an output phosphor screen. The incoming image is converted to an electron image. High-voltage acceleration of the imaging electrons, together with demagnification between the input target and the output screen, contributes to the production of a bright, visible image.

The tube's evacuated glass envelope supports the input phosphor screen, 22 cm in diameter. The input target (approximately 0.4 mm thick) consists of a neutron scintillator and a photoemissive layer. This scintillator is a powder mixture of lithium fluoride and ZnS(Ag) in a weight ratio of 1:4. To provide this powder mixture with a high neutron cross-section for a prompt neutron-alpha reaction, LiF is 95.72% enriched with Li-6. Absorption of a neutron by the scintillator results in the emission of an alpha particle. As a result, the ZnS (Ag) phosphor is stimulated to emit light. The light causes the emission of electrons from the adjacent photoemissive layer. The electrons emitted from the



photoemissive layer are accelerated toward the phosphor output screen by a voltage of about 30 kV. The final light output of the phosphor screen is a bright image of the incident neutron pattern.

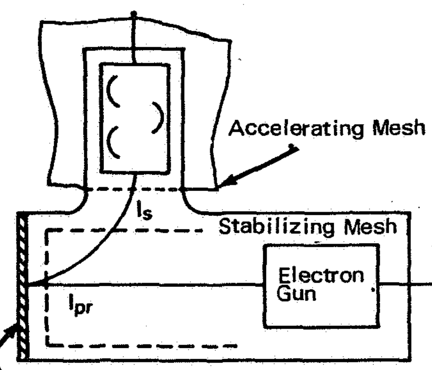
The neutron image obtained at the intensifier tube output is observed by means of a 525-line, 30-frame/sec, interlaced, closed circuit television system. A vidicon system can be used for neutron intensities as low as 2×10^4 n/cm^2 sec.

Source: H. Berger and I. Kraska
Argonne National Laboratory
and W. Niklas and A. Schmidt of
The Rauland Corp.
under contract to
Argonne National Laboratory
(ARG-120)

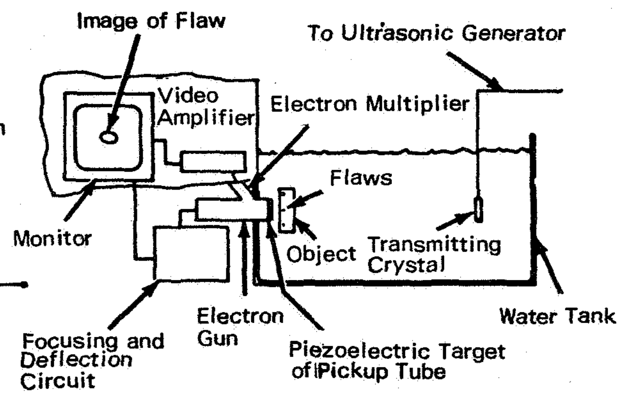
Circle 14 on Reader Service Card.

CAMERA TUBE FOR IMPROVED ULTRASONIC INSPECTION

An electron multiplier, incorporated into the camera tube of an ultrasonic imaging system, improves resolution, effectively shields low level circuits, and provides a high level signal input



Ultrasonic Camera Tube



Ultrasonic Inspection System

to the television camera. The multiplier amplifies the secondary electron beam within the camera tube to a level 10^5 to 10^6 times greater than the threshold value. The multiplier also serves as a wide-band amplifier having extremely good noise characteristics. The tube sensitivity is set by the piezoelectric plate's ability to modulate the secondary emission electrons without the need for a great deal of shielding, as is the case for tubes without the multiplier.

The improved system is effective for inspection of metallic materials for bonds, voids, and homogeneity, which are not detectable by conventional methods. The system is currently being evaluated for application in medical diagnostics.

The improved ultrasonic camera tube is shown on the left. The accelerating potential of the electron gun is 1000 volts. I_{pr} is the primary electron current; I_s is the secondary emission current. The accelerating mesh is maintained at a potential 400 volts above the stabilizing mesh. The electron multiplier has 10 stages with 100 volts/stage.

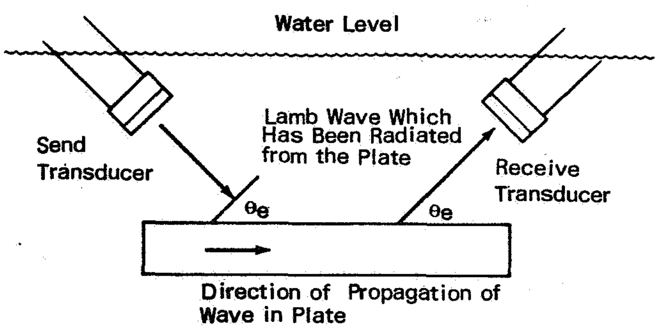
The secondary electrons, produced on the 5-cm-diameter barium titanate piezoelectric target by the high velocity scanning electron beam, are accelerated into the electron multiplier by the accelerating mesh, producing high level output. The secondary electron beam is modulated by the voltage generated by the piezoelectric target. The target is irradiated by an impinging ultrasonic field.

The diagram of the entire ultrasonic imaging inspection system set up for a through-transmission inspection is shown on the right. (Reflection techniques may also be used.) The far field ultrasonic pattern provides a uniform ultrasonic intensity for a shadow-type image.

Following detection and amplification in the pickup tube, the amplified video signal is presented by a conventional television system. The image of any discontinuity is then reproduced on the observation monitor.

Source: H. Berger
Argonne National Laboratory
and J. E. Jacobs, and W. J. Collis of
Northwestern University
under contract to
Argonne National Laboratory
(ARG-90237)

No further documentation is available.



LAMB-WAVE TECHNIQUE GIVES INCREASED SENSITIVITY IN ULTRASONIC TESTING

Lamb waves offer improved sensitivity and resolution for the. detection of small defects in thin plates and small-diameter thin-walled tubing. This improvement over conventional shear wave techniques applies to both longitudinal and transverse flaws in the specimens.

Lamb waves consist of an infinite number of modes of vibration that can be generated in elastic materials. In a given material, each Lamb-wave mode has a different velocity of propagation (phase velocity), dependent upon the thickness of the specimen, the wave frequency, the order of the mode, and the material in which the wave is generated. Thin plates are most suitable for generating and detecting Lamb waves at ultrasonic frequencies.

Lamb waves can be generated in thin specimens in the manner shown in the figure: A longitudinal sound wave with a speed V is sent through a coupling medium, usually water, such that it strikes the plate specimen at angle θ_i. The speed at which the line of contact of any wave front runs along the surface of the plate is

$$V_a = V_L / \sin \theta_i$$

If the speed V_a equals the phase velocity of a Lamb-wave mode, the mode is generated in the plate by a resonance process. The wave travels down the plate and radiates from it, along the entire length, with an exit angle θ_e equal to $_i$. A receiving transducer, positioned at angle $_e$, will detect this energy, which can be amplified and displayed.

Once a Lamb-wave is generated, it will continue to travel down the plate, attenuated but otherwise undisturbed, until it reaches a discontinuity such as the edge of the plate or a flaw. A flaw or crack is easily detectable because at that point the phase-velocity frequency thickness product is not satisfied and the Lamb-wave mode does not appear. A receive transducer aimed at this flaw area thus indicates the presence of the flaw by the absence of a signal.

A flaw can also be detected using one transducer as both sender and receiver. In this configuration, no signal is received until the Lamb-wave reaches a discontinuity. The wave is, in part, reflected from the discontinuity and travels back along the plate. It also is radiated from the plate at an exit angle Θ_e equal to Θ_i, and thus can be detected by the same transducer that was used to generate it.

Source: R. DiNovi
Argonne National Laboratory
(ARG-10009)

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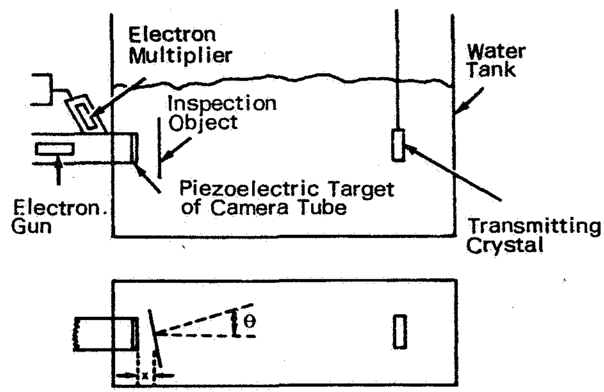
ULTRASONIC TV IMAGES IMPROVED BY USE OF LAMB-WAVE SPECIMEN ORIENTATION

The illustrated Lamb-wave orientation technique, in which the sample under investigation is oriented at a slight angle to the incident wave, can minimize the interference from standing waves in continuous wave ultrasonic television imaging techniques. Repeated ultrasound reflection between the test object and the detector can cloud the TV image and cause confused images of the sample.

The new inspection technique utilizes a commercially available ultrasonic television imaging system and a Lamb-wave approach, in which the sample is placed in the inspection position at an angle Θ, other than the normal angle of incidence. The orientation angle depends upon the ultrasonic frequency and the sample material.

A two-fold advantage results from the Lamb-wave orientation technique. First, mounting a thin, flat specimen at an angle tends to eliminate standing wave interference in the ultrasonic image. Ultrasound that would otherwise reflect back and forth between the object and the detector is essentially removed from the image area. Second, placement of the sample at the proper angle for generating a first-order

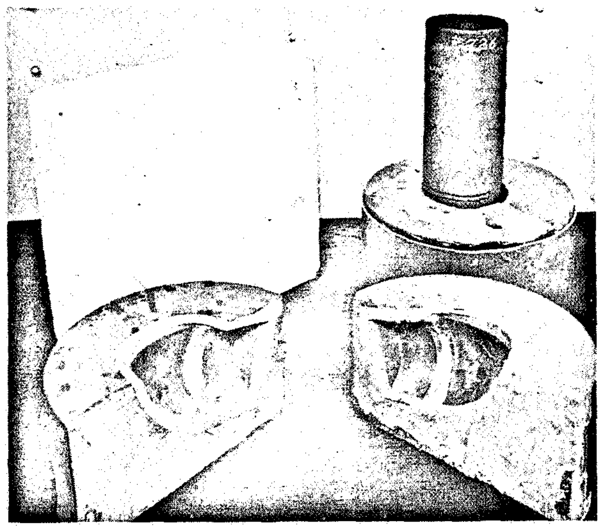


Partial Views of the Television Imaging System (Side View, Upper; Top View, Lower) Showing Angulation of Flat Inspection Objects

Lamb-wave mode can improve the results by increasing ultrasonic transmission and improving sensitivity to the sample's internal flaws.

Source: H. Berger
Argonne National Laboratory
(ARG-203)

No further documentation is available.



POLYURETHANE FOAM FIXTURE FOR ULTRASONIC INSPECTION

Rigid polyurethane foam fixtures have proved superior to conventional jigs for holding complex parts during ultrasonic testing. Foamed in-place plastic can be used to simultaneously jig, sound-insulate, and seal the test object. For complex shapes, considerable savings in labor and time are possible.

Previously, metal jigging was used for supporting ultrasonic test objects. Cork was applied for sound insulation around holes and edges. Paint sealants provided water-proofing. Complex parts often could not be inspected with existing tooling. In many cases, the time required for tooling made inspection impractical.

With the new system, the complete hardware is embedded in foam, which is then machined to the appropriate configuration for inspection. After inspection, the foam is readily removed from the part.

Foam packaging is already in widespread usage. The use of foam holding fixtures for other inspection operations appears feasible. With refinement and materials improvement, foam fixturing may be used in various manufacturing processes.

Source: C. C. Kammerer and
F. H. Stuckenberg of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-17092)

No further documentation is available.

PORTABLE ULTRASONIC C-SCAN SYSTEM

A lightweight, portable, ultrasonic C-scan recording system has been used to inspect bonds in honeycomb structures and other restricted areas. It has potential uses in many fields, since it allows spot checks of small regions to be recorded without the expense of transporting an entire assembly and mounting it on a permanent ultrasonic recording fixture.

The unit incorporates the following advantages over prior apparatus: 1) Low unit weight (less than 7.8 kg) permits direct attachment of the unit even to thin-walled test objects. 2) Direct attachment of the sensor to the object gives better measuring accuracy than systems where the sensor is only positioned nearby. 3) The suction disc unit used to attach the sensor to the object incorporates a screw adjustment mechanism for precisely positioning the sensor. 4) Specially designed, double row bearings reduce friction in the sweep and recorder units. 5) A ball-chain drive enables the recorder to be in a different orientation than the sensor and sweep unit. 6) A novel, laminar-flow squirter head reduces the flow noise level received by the sensor. This head is described separately in the succeeding item (MFS-16977).

Source: W. McMahon and D. L. Norris of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16950)

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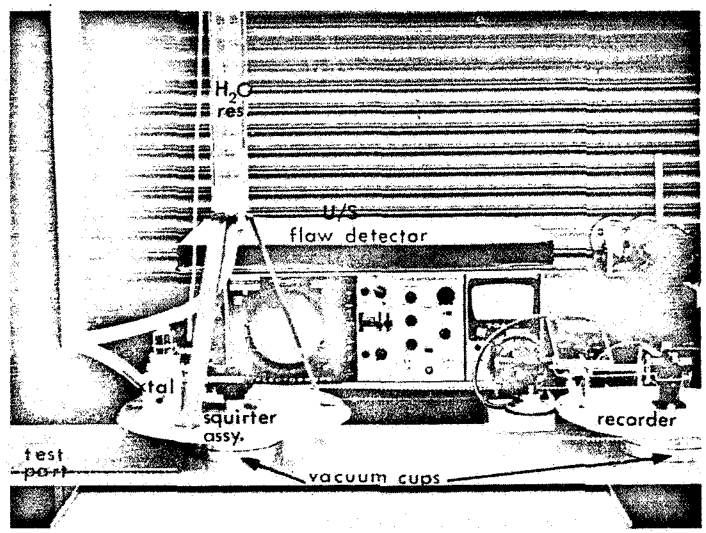
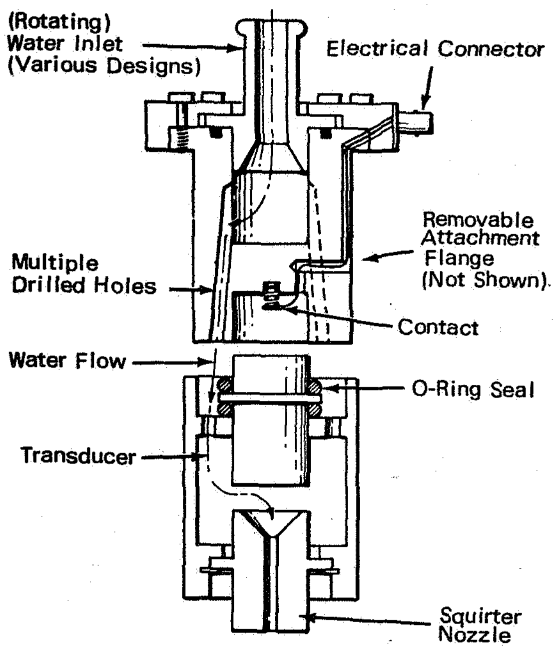


LAMINAR-FLOW SQUIRTER FOR ULTRASONIC INSPECTION EQUIPMENT

The figure shows cross-sectional details of the new type ultrasonic squirter head referred to in the preceding item.

Current squirter head designs use a single-inlet, side-entrant flow system. This produces



high turbulence at the nozzle entrance. The smoother, laminar flow of the new design results in more uniform distribution of the ultrasonic energy in the squirter jet and gives better scan resolution.

Laminar flow is produced by introducing the fluid through multiple small holes around the perimeter of a cylindrical body. The design, besides giving improved scan resolution, also permits use of a rotary connection to enable spiral scanning.

Source: C. C. Kammerer and W. McMahon of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-16977)

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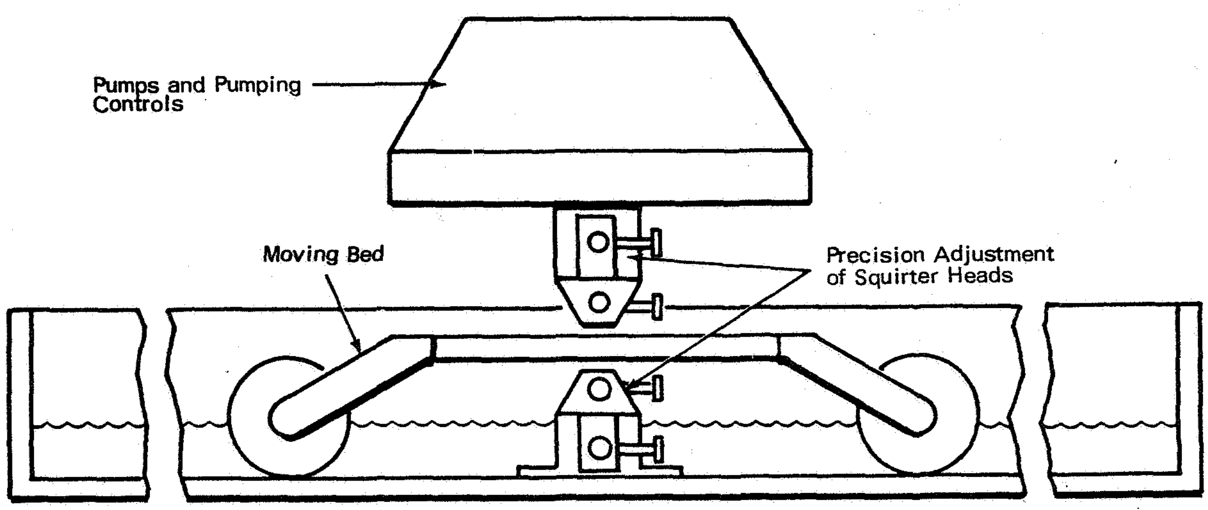
FIXED-HEAD, MOVING-BED, ULTRASONIC C-SCANNER

The figure is a sketch of a novel ultrasonic test setup, in which the ultrasonic squirter head and receiver transducer are fixed, and the test object is moved beneath them. The precision alignment and reduced vibration obtained with this arrangement result in improved image resolution.



Operation of this unit has been demonstrated in the laboratory. With refinements, the new apparatus could offer as many advantages over regular C-scan equipment as moving-bed milling machines have over their older moving-head counterparts.

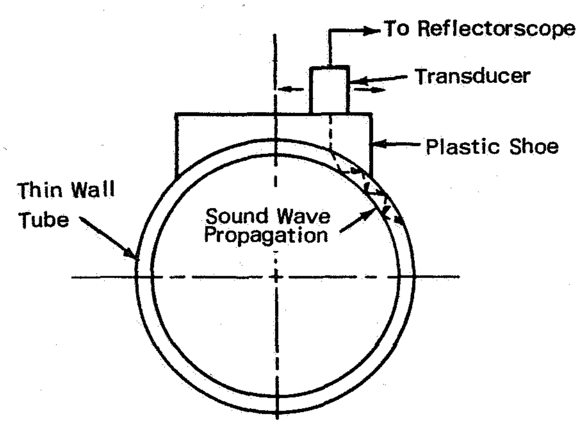
Source: F. H. Stuckenberg, C. C. Kammerer
and W. McMahon of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15758)

No further documentation is available.

PLASTIC SHOE SIMPLIFIES ULTRASONIC INSPECTION OF THIN-WALLED METAL TUBING

In inspecting thin-walled stainless steel welded tubing to locate critical defects, incorporation of a plastic shoe into available ultrasonic inspection equipment enables the transducer to be coupled to the tube at various desired incidence angles.

As shown in the illustration (not to scale), a plastic shoe is fabricated with a curvature that corresponds to the tube wall. The tube surface and the plane surface of the shoe are coated with a water solution of glucose. This coating couples the transducer to the metal tubing, permits the transducer to be moved varying distances from the tube centerline, and allows the plastic shoe to be rotated about the tube circumference or moved along its length. By moving the transducer back and forth from the tube centerline, desired incident angles of sound propagation throughout the tube wall can be obtained. This technique permits complete and thorough inspection of the metal tube.



Source: R. M. Peterson and
D. J. Lambermeyer of
Aerojet General Corp.
under contract to
Space Nuclear Systems Office
(NUC-10010)

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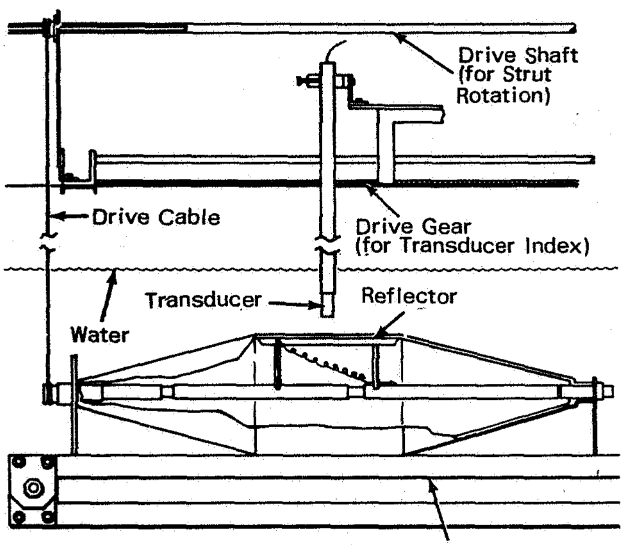

REFLECTOR PLATE ENABLES ULTRASONIC INSPECTION OF TUBULAR COMPONENTS

In ultrasonic pulse-echo inspection of thin-walled, tapered cylindrical structures, a reflector plate is needed within the structure to return the ultrasonic energy. Because the ends of the particular structure shown in the illustration taper into small-diameter threaded bushings, a very limited opening is available for insertion of a reflector plate.

The illustrated reflector plate design has been developed to solve this problem. The plate can be collapsed into a tubular assembly small enough to fit through a 19 mm bushing. Two assemblies have been built. One (shown) is used to test the cylindrical segment of the structure; the other, slightly modified, fits the conical segments.

Source: G. W. Kurtz and G. H. Leinbaugh
Marshall Space Flight Center
(MFS-21360)

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HANDBOOKS ON ULTRASONIC TESTING

Four handbooks have been prepared for use in teaching metal parts inspectors and quality assurance technicians the fundamentals of nondestructive testing using ultrasonic methods. The handbooks contain comprehensive information on the subject of ultrasonic testing, and can be effectively used in the shop or laboratory, or as study texts in technical schools and in the home.

The handbooks may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $0.95)
Reference:
NASA-CR-61288 (N68-28790) Ultrasonic Testing
NASA-CR-61209 (N68-28781) Non-

destructive Testing, Ultrasonic Basic Principles
NASA-CR-61210 (N68-28782) Nondestructive Testing, Ultrasonic Equipment
NASA-CR-61211 (N68-28783) Nondestructive Testing, Ultrasonic Applications

Source: General Dynamics/Convair Div.
under contract to
Marshall Space Flight Center
(MFS-20409)

HANDBOOKS ON EDDY CURRENT TESTING TECHNIQUES

Three handbooks have been prepared that explore principles of nondestructive testing by eddy current techniques.

The handbooks could serve as basic instruction manuals and guides for anyone engaged in the nondestructive testing of metal parts and components.

The handbooks are dated January 1, 1967 and are titled as follows:

1. Eddy Current Testing, RQA/M1-533.17 (298 pages).
2. Nondestructive Testing Eddy Current Basic Principles, RQA/M1-5330.12 (V-I) (207 pages).
3. Nondestructive Testing Eddy Current Equipment, Methods and Applications, RQA/M1-5330.12 (V-II) (203 pages).

Source: General Dynamics/Convair Div.
under contract to
Marshall Space Flight Center
(MFS-13172)

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TRAINING MANUALS FOR MAGNETIC PARTICLE TESTING

Two training manuals or handbooks have been prepared on nondestructive testing using magnetic particles as detection media. This relatively simple method of nondestructive testing has been used for many years to test finished metallic components, billets, hot-rolled bars, and forgings. Magnetic particle testing involves magnetization of the test specimen, application of the magnetic particles, and interpretation of the patterns formed by the particles.

The manuals are dated January 1, 1967, and are titled as follows:

1. Nondestructive Testing Magnetic Particle, RQA/M1-5330.11 (410 pages).
2. Magnetic Particle Testing, RQA/M1-5330.16 (149 pages).

The manuals are designed primarily for home study and the classroom. They can be used by students in technical schools, and by test personnel and quality assurance specialists in any industry where nondestructive testing of metal parts is essential.

Source: General Dynamics/Convair Div.
under contract to
Marshall Space Flight Center
(MFS-20187)

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INSTRUCTION MANUALS ON LIQUID PENETRANT TESTING

Two manuals have been published that provide basic information on liquid penetrant testing. Volume 1, a programmed instruction text with 276 pages, presents the fundamental concepts in a form suitable for individual self-instruction. It moves at the slow, careful, very thorough pace necessary for the initial training of a person who has no previous acquaintance with the subject. Many illustrations are included. Photographs, line art, illustrative cartoons, and process flow charts reinforce the logical, page by page progression of ideas from general concepts, through equipment and procedures, to the applications and need for liquid penetrant testing.

The second volume, 129 pages in standard text format, reviews and builds on the material introduced in the first volume. It moves considerably faster and with much greater detail, in accordance with its intended use as a classroom textbook or reference work. It covers such topics as: 1) scope of application and reasons for use of liquid penetrant testing; 2) equipment and materials used; 3) actual test procedures and interpretation of test results; 4) safety precautions and quality control of testing materials; and 5) comparison of liquid penetrant testing with other nondestructive testing processes. Many photographs and drawings show the appearance of defects found both by liquid penetrant and by other nondestructive means of testing.

Source: General Dynamics/Convair Div.
under contract to
Marshall Space Flight Center
(MFS-14010)

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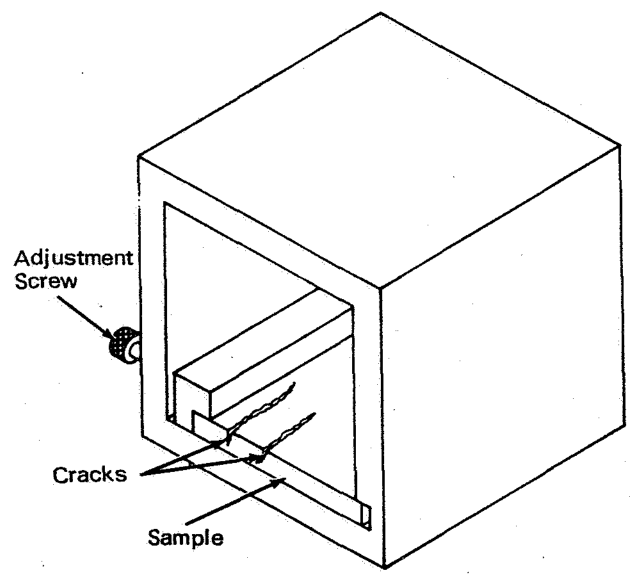
DYE PENETRANT EVALUATION DEVICE

The illustration shows a device which provides calibrated-width cracks in metal plates, for use in the evaluation of dye penetrants. Cracks are developed in metal samples by thermal shock (heating and quenching). A penetrant is applied to reveal the crack locations, and the samples are trimmed to fit the container. The trimming also exposes cracks on the edge of the plate, for metallographic examination.



After removal of the penetrant, the samples are polished, ultrasonically cleaned, and installed in the container. An adjustment screw permits a crack to be compressed to a desired width, which can be verified by observation with the metallograph. Dye penetrant materials can then be compared for effectiveness by a cyclic process of penetrant exposure, metallographic examination, and ultrasonic cleaning.

Source: C. Wages of
Spaco, Inc.
under contract to
Marshall Space Flight Center
(MFS-20656)

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DYE PENETRANT SURFACTANT WILL NOT REACT WITH LIQUID OXYGEN

Hexachlorobutadiene may be blended into a mixture of commercially available liquid penetrant surfactants to produce a surfactant that is insensitive to liquid oxygen.

Metal surfaces to be nondestructively inspected for flaws by the dye-penetrant method must be cleaned with a surfactant before and after application of the dye. Although dye penetrants that are insensitive to liquid oxygen are now available, unmodified commercially available surfactants cannot be safely used in the presence of this strong oxidant.

The surfactants to be blended with the hexachlorobutadiene may contain nonionic and ionic components. A typical formulation by weight consists of 68% hexachlorobutadiene, 20% polychlorinated polyphenyl, and 12% surfactants based on alkaryl polyether alcohols, sulfonates, and sulfates.

Source: North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-475)

Circle 24 on Reader Service Card.

DETECTING SURFACE CRACKS WITH MICROWAVES

A microwave unit has been developed that can detect cracks and scratches as narrow as 4 μm in a metal surface. The unit may be applied to continuously observe the growth of flaws during fatigue or fracture tests.

A microwave transmitter irradiates a flawed metal surface with microwave energy. The microwaves re-emitted from the surface exhibit a pattern of eigenmodes different from those of the original signal. The generation of a spatial periodic signal with a polarization modulator induces a characteristic received pattern. This pattern is correlated either with an inserted reference pattern or autocorrelated with itself to detect a change in the surface properties of the test specimen.

Source: L. Feinstein and R. Hruby
Ames Research Center
(ARC-10009)

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